

CLAIMS

1. Apparatus for amplifying an optical signal, said apparatus comprising:

5 a pump system disposed to inject optical pump energy into a first end of a first fiber segment so as to counter-propagate relative to an optical signal traversing said first fiber segment and a second fiber segment; and

an optical filter structure coupled to a second end of said first fiber segment and a first end of said second fiber segment; and

10 wherein said optical signal propagates through said optical filter structure from said second fiber segment to said first fiber segment, said optical pump energy propagates through said optical filter structure from said first fiber segment to said second fiber segment, and said optical filter structure substantially blocks energy at a frequency of said optical signal from traveling from said first fiber segment into said second fiber segment so that Raman amplification is induced in said first fiber segment and said
15 second fiber segment and double Rayleigh backscattering effects are ameliorated.

2. The apparatus of claim 1 wherein said optical filter structure comprises:

a circulator having a first port, a second port, and a third port; and

20 a fiber Bragg grating configured to reflect optical energy at a frequency of said optical pump energy and to absorb optical energy at a frequency of said optical signal.

3. The apparatus of claim 2 wherein said optical pump energy enters said third port of said circulator from said first fiber segment, exits said first port of said circulator,

reflects from said fiber Bragg grating into said first port of said circulator and exits said second port of said circulator into said second fiber segment.

- 5 4. The apparatus of claim 2 wherein reflections of said optical signal enter said third port of said circulator from said first fiber segment, exit said first port of said circulator and are not reflected by said fiber Bragg grating.

- 10 5. The apparatus of claim 2 wherein said optical signal enters said second port of said circulator from said second fiber segment and exits said third port of said circulator into said first fiber segment.

- 15 6. The apparatus of claim 1 further comprising:
an isolator coupled to a second end of said first fiber segment and configured to pass optical energy into said first fiber segment via said second end and block optical energy from exiting said second fiber segment via said second end.

- 20 7. The apparatus of claim 1 further comprising:
said first fiber segment and said second fiber segment.

8. The apparatus of claim 1 further comprising:
an additional optical filter structure coupled to a second end of said second fiber segment and a first end of a third fiber segment.

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wherein said optical signal propagates through said additional optical filter structure from said third fiber segment to said second fiber segment, said optical pump energy propagates through said optical filter structure from said second fiber segment to said third fiber segment, and substantially blocks energy at a frequency of said optical signal from traveling from said second fiber segment into said third fiber segment so that Raman amplification is also induced in said third fiber segment.

9. The apparatus of claim 1 wherein said optical pump energy comprises:

a first optical pump signal at a first frequency; and
a second optical pump signal at a second frequency.

10. A method for amplifying an optical signal, said method comprising:

injecting optical pump energy into a first end of a first fiber segment so that said optical pump energy counter-propagates relative to an optical signal traversing said first fiber segment and a second fiber segment;

passing said optical signal from said second fiber segment into a second end of said first fiber segment;

passing said optical pump energy from said first fiber segment into said second fiber segment; and

blocking optical energy at a frequency of said optical signal from entering said second fiber segment from said first fiber segment.

11. The method of claim 10 wherein passing said optical signal comprises:

5 said first fiber segment.

12. The method of claim 10 wherein passing said optical pump energy comprises:

reflecting said optical pump energy from a fiber Bragg grating and back into said first port of said circulator, out said second port of said circulator and into said second fiber segment.

passing said optical energy at said frequency of said optical signal into a third port of a circulator and out of said second port of said circulator; and

14. The method of claim 10/ further comprising employing an isolator to block said optical pump energy from exiting a second end of said second fiber segment while permitting said optical signal to enter said second end of said second fiber segment.

15. The method of claim 10 wherein injecting optical pump energy comprises:

injecting a first optical pump signal at a first frequency; and
 injecting a second optical pump signal at a second frequency different than said
 first frequency.

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16. Apparatus for amplifying an optical signal, said apparatus comprising:
 means for injecting optical pump energy into a first end of a first fiber segment so
 that said optical pump energy counter-propagates relative to an optical signal traversing
 said first fiber segment and a second fiber segment;

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wavelength-selective means for reflecting optical energy at a frequency of said
 pump energy, optical energy at a frequency of said optical signal being absorbed by said
 wavelength-selective reflecting means;

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means for directing optical energy exiting a first end of said second fiber segment
 into a second end of said first fiber segment, for directing optical energy exiting said
 second end of said first fiber segment into said wavelength-selective reflecting means,
 and for directing optical energy reflecting from said wavelength-reflective means into
 said first end of said second fiber segment.

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17. The apparatus of claim 16 wherein said wavelength-selective reflecting means
 comprises a fiber Bragg grating.

18. The apparatus of claim 16 wherein said directing means comprises a three-port
 circulator.

19. The apparatus of claim 16 wherein said optical pump energy comprises a first pump signal at a first frequency and a second pump signal at a second frequency different than said first frequency.

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20. The apparatus of claim 19 wherein said wavelength-selective reflecting means comprises:

a first fiber Bragg grating configured to reflect optical energy at said first frequency; and

10 a second fiber Bragg grating configured to reflect optical energy at said second frequency.

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